Isolation Fault Troubleshooting - Application Note

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Introduction

In photovoltaic systems with a transformer-less inverter, the DC is isolated from ground. Modules with defective module isolation, unshielded wires, defective power optimizers, or an inverter internal fault can cause DC current leakage to ground (PE - protective earth). Such a fault is also called an isolation fault.

This document describes how to identify and locate an isolation fault in a SolarEdge system.

WARNING!

This guide is intended to aid in troubleshooting a SolarEdge installation which has a ground fault. Persons using this guide should be completely familiar with SolarEdge systems, their concept of operation, safety features, and all applicable safety procedures and requirements. Do not attempt any troubleshooting without adequate safety equipment and a thorough understanding of all procedures.

WARNING!

Troubleshooting of PV systems may involve exposure to hazardous voltage levels and should be conducted by qualified personnel only. Presence of ground faults in PV systems may result in hazardous voltages or currents on normally grounded conductors or exposed metal elements. Extreme caution must be used when troubleshooting PV systems with ground faults.

Identifying an Isolation Fault

Every time the SolarEdge inverter enters operational mode and starts producing power, the resistance between the ground and the DC current-carrying conductors is checked. The inverter displays an isolation error when it detects a total combined isolation resistance of less than 600kΩ in single phase inverters, or 1MΩ in three phase inverters.

If an isolation error occurs, the LCD displays error 25 (single phase inverters) or 121 (three phase inverters):

```
Error  xxxx
Isolation  fault
See  diagnostics
```

An isolation fault may disappear and recur after a short period (especially if it is caused by morning moisture), therefore it is recommended to troubleshoot the fault as soon as it occurs, before it may temporarily disappear. Before troubleshooting on site, you may check the isolation value in the SolarEdge monitoring portal. If the value is borderline (within 10%) or below the limit (600kΩ for single phase inverters / 1MΩ for three phase inverters), troubleshoot the fault on site. If the value is at least 10% higher than the limit, it is better to wait until an isolation fault error recurs.

► To check the isolation value in the monitoring portal:

1. In the **Layout** window right-click on the inverter and select **Choose operations ➔ Reset**.
2. Right-click on the inverter and select **Info** to display information about the inverter.
3. In the **General** parameter list, check the **Last Isolation Value**.

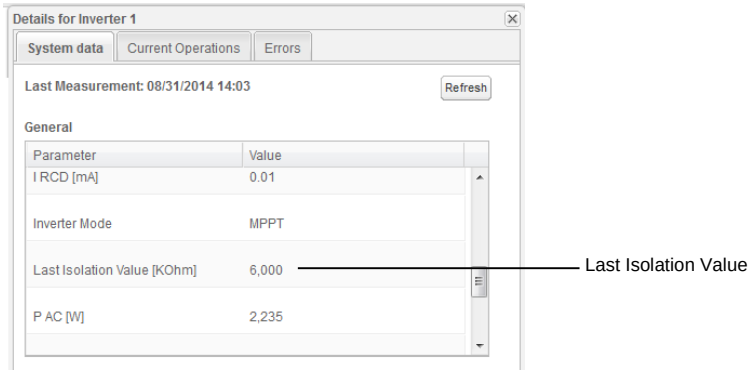


Figure 1: System data tab in the Details window

The next sections describe how to identify the source of an isolation fault if Error 25 or 121 are displayed. You can troubleshoot the isolation fault using the following methods:

- Using the inverter diagnostics screen in the inverter LCD display. This method is available from DSP1 firmware version 1.13.181 in three-phase inverters, and 1.210.693 in single phase inverters. The version can be checked from the ID status screen of the LCD.
- Using an insulation tester (Megger).

Troubleshooting an Isolation Fault Using the Inverter Diagnostics Screen

During the troubleshooting process, strings and/or power optimizers will be disconnected. Every time this is done, make sure to perform the following steps:

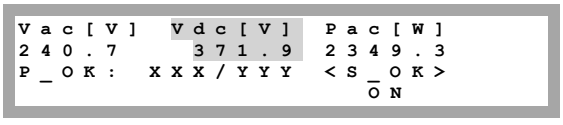
a. Turn the inverter ON/OFF switch at the bottom of the inverter to OFF. If a Safety Switch or a DC isolation switch is installed, it should remain ON.

b. Wait until the DC voltage is safe.

c. Remove the required string, power optimizer or module.

d. Turn the inverter ON, and check that V_{dc}, shown in the inverter screen below, is approximately the nominal DC voltage according to the following table:

Inverter type	Europe & APAC	North America	Unit
One phase	350	350	Vdc
Three phase	750	SE9KUS: 400 SE10KUS and SE20KUS: 850	Vdc



At this point, the inverter checks the isolation status. If V_{dc} does not reach the nominal voltage, perform pairing. For information on the pairing process, refer to the *SolarEdge Installation Guide*.

Locating the Leaking String

1. If multiple strings are connected to the inverter, find the faulty string by connecting one string at a time to the inverter and checking if the error is still displayed (following steps a-d above).
2. Verify that only the faulty string is connected to the inverter. If there is more than one faulty string, check each string separately.

Locating the Leakage within a String

1. Enter the isolation status screen by pressing and holding down the LCD light button until the following message is displayed:

```
Keep holding button
for pairing, release
to enter menu...
Remaining 3sec
```

2. Release within 5 seconds to enter setup mode.
3. Short-press (one second) to scroll down to the **Maintenance** menu and long-press to enter the menu. The following screen is displayed:

```
Date and Time
Reset Counters
Factory Reset
SW Upgrade-SD Card
AFCI <En>
Manual AFCI Test
Diagnostics
```

4. Short-press to scroll down to the Diagnostics menu and long -press to select **Diagnostics ➔ Isolation Status**. The following status screen is displayed:

```
R Iso 400 kOhm
DC+ DC-
|-------*----------|
<40.3%>
```

R Iso: The value of the isolation resistance (in kOhm)
The asterisk (*) and the percentage value indicate the approximate location of the fault within the string, relative to DC+:

- 0% indicates the fault is at DC+
- 100% indicates the fault is at DC-

5. Using the screen, identify the fault source area: Multiply the number of power optimizers in the string by the percentage value. The result is the module near which the fault occurred. For example, in a string with 15 modules and power optimizers and a percentage value of 55%: 15*55% = 8.25. This means that the fault is near module #8, counted from the DC+ side.
6. Check if there are damaged connectors or DC wires between the suspected power optimizer and its module and between the suspected power optimizer and its neighboring power optimizers. If there are, replace them and recheck the isolation status by turning ON the inverter as described in step d. If the fault persists, proceed to step 7.
7. Remove the suspected fault source by disconnecting the suspected power optimizer from the string (following steps a-d above). Use a DC extension cable with MC4 connectors (male at one end and female at the other end) to bypass the removed power optimizer. Recheck the isolation status.
   - If after startup/pairing the fault is eliminated, the fault is in the removed module/power optimizer. Proceed to step 9.
   - If after startup/pairing the fault re-appears, the leakage source is not in the removed module/power optimizer but near it.
8. Reconnect the module/power optimizer in the string.
   Check the modules/power optimizers before and after the suspected location by repeating steps 7 and 8, one module/power optimizer at a time. If the fault re-appears, check the next modules/power optimizers one a time.
   The location of the fault is detected with an accuracy of ±1 for single phase inverters and ±2 for three phase inverters. If after checking around this tolerance the problem was not found, the string might have multiple isolation faults. In this case, you should use an isolation tester as described in the *Troubleshooting an Isolation Fault Using an Insulation Tester*, below.
9. Find whether the leakage is from the module or from the power optimizer:
   a. Disconnect the suspected module from the suspected power optimizer.
   b. Turn OFF the inverter.
   c. Connect the power optimizer to the string.
   d. Turn the inverter ON, and check that V_{dc} is approximately the nominal DC voltage (refer to the table above). Otherwise, perform pairing.
   e. If after startup/pairing the fault is eliminated, the fault is in the module that was removed. If the fault re-appears, the power optimizer is the leakage source.
10. Repair or replace the faulty component.
11. Perform pairing. For information on the pairing process, refer to the *SolarEdge Installation Guide*.

Troubleshooting an Isolation Fault Using an Insulation Tester

In this procedure, you check the resistance of system components, drilling-down from string level, through power-optimizer/module pairs, and finally a single component – a power optimizer or a module. You also check the wiring between components.

For this procedure, use an insulation tester and a connector branch cable[1].

1. Turn OFF the inverter ON/OFF switch, and wait until the LCD indicates that the DC voltage is safe (<50V), or wait five minutes before continuing to the next step.

WARNING!

If you cannot see the inverter panel, or if a malfunction is indicated on the LCD panel, wait five minutes for the input capacitors of the inverter to discharge.

2. Disconnect all the DC cables connecting the strings to the inverter or the Safety Switch.
3. Test the resistance of the *extension DC cables* between the strings (or the combiner box) and the inverter (home-run cables): Disconnect the home-runs at both ends and measure each wire by connecting it to the positive probe, while the negative probe remains connected to the ground.
   If the wiring resistance is less than 200MΩ, the wire is faulty; replace any faulty wires. If the wiring resistance is 200MΩ or more, the fault is in the string that was connected to this extension cable; check the string (without the extension cable) as described in the following step.
4. Test the *string resistance* using the insulation tester (see Figure 2):
   a. Verify safe string voltage and current: max. 50V and 500mA.
   b. Connect the positive and negative connectors of the first or last optimizer in the string to the branch cable.
   c. Connect the positive probe of the insulation tester to the branch cable.
   d. Connect the negative probe of the insulation tester to a ground point.
   e. Select 500V testing on the insulation tester.
   f. Test the insulation.

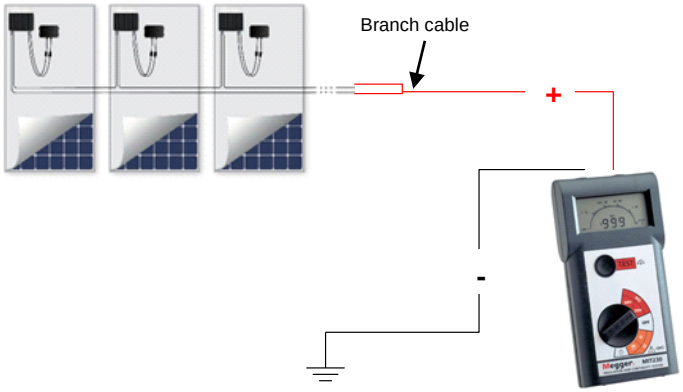


Figure 2: Connecting the insulation tester to the PV string

If the resistance is less than 600kΩ in a single phase inverter or less than 1MΩ in a three phase inverter, continue checking this string's components to isolate the source of leakage, as detailed in the following steps. Always make sure to connect both negative and positive output connectors to the tester using a branch cable.

5. Test the *power optimizers' and modules'* resistance using the insulation tester (see Figure 3):
   a. Disconnect the power optimizer from the string; it should remain connected to the PV module.
   b. Verify safe power optimizer voltage and current: max. 1V and 500mA.
   c. Connect the power optimizer's positive and negative *output* connectors to the branch cable.

WARNING!

Connecting the insulation tester to just one of the power optimizer connectors or to just one of the DC cables may cause irreversible damadge to the power optimizer.

   d. Connect the positive probe of the insulation tester to the branch cable.
   e. Connect the negative probe of the insulation tester to a ground point.

[1] Branch cables can be purchased from SolarEdge (for details refer to datasheet at the following link http://www.solaredge.com/files/pdfs/products/power-optimizers/se_branch_cables_datasheet.pdf), or use a branch cable with the appropriate connectors.

f. Select 500V testing on the insulation tester.

g. If the measured resistance is 200MΩ or more, the power optimizer and module are not faulty. If the measured value is less than 200MΩ, the optimizer, the module or both are faulty. Continue checking as detailed in the following steps.

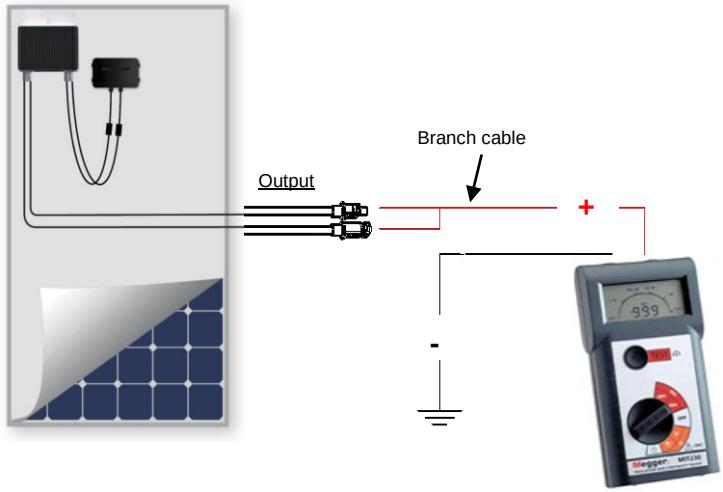


Figure 3: Connecting the insulation tester to the power optimizer and module

6 Find whether the leakage is from the module or from the power optimizer. Test each component individually by measuring the resistance between negative wires and ground:

a. Disconnect the module from the power optimizer.

b. Connect the power optimizer's positive and negative *output* connectors to the branch cable (see Figure 4).

c. Connect the positive probe of the insulation tester to the branch cable.

d. Connect the negative probe of the insulation tester to the power optimizer frame (ground point).

e. Select 500V testing on the insulation tester.

f. Measure the resistance; if the value is 200MΩ or more – the module is faulty; if the value is less than 200MΩ, replace the optimizer and test the module in case it is faulty as well.

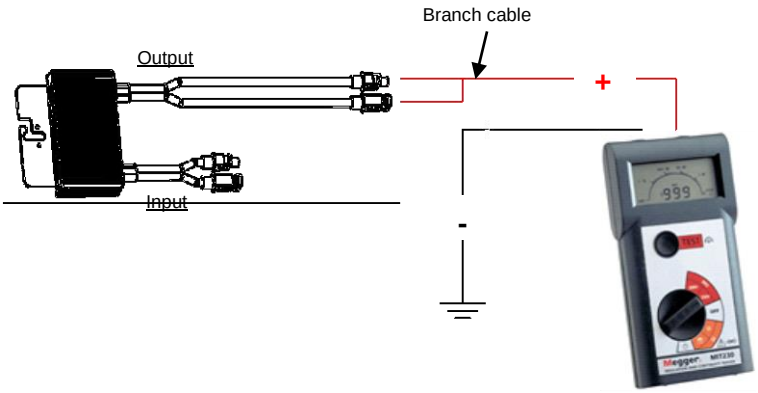


Figure 4: Connecting the insulation tester to the power optimizer

g. Disconnect the branch cable from the power optimizer and connect it to the module (see Figure 5)

h. Measure the resistance; if the value is 500MΩ or more – the module is OK; if the value is less than 500MΩ, the module is faulty.

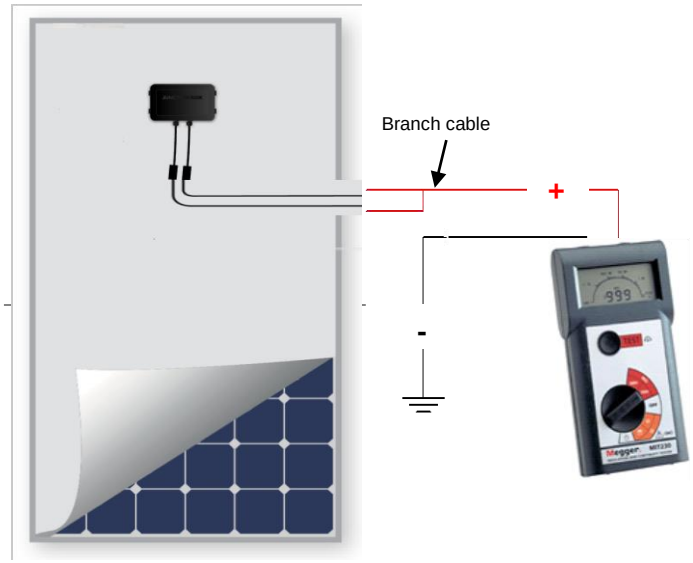


Figure 5: Connecting the insulation tester to the module

7 Replace the faulty component(s).

NOTE

If you replace power optimizers, repeat the pairing process. For information refer to the *SolarEdge Installation Guide*.